***** DRAFT – FOR DISCUSSION PURPOSES ONLY *****

The Northern Goshawk and Forest Management on Private Lands in Northern California

Summary of Ecological Information

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Background

This document presents a summary of biological knowledge on northern goshawks (*Accipiter gentilis*) in northern California. The data presented in this document focuses on providing information pertaining to the following issues:

1) population trends and distribution data of goshawks in California;
2) goshawk life cycle requirements and related habitat needs; and
3) effects of forest management on the first two items.

What information should be used for assessing the ecology of goshawks in northern California?

For subjects for which local data are available, statements in this report are based on studies in California, and preference is given to quantitative studies with statistical qualifiers. Such data are presented in "stand alone" figures throughout the text. Where local information or quantitative studies are not available on a particular subject (e.g., size of post fledgling area), studies from similar forest types in nearby Western states (e.g., Ponderosa pine forest in Arizona) and the professional judgement and reasoned theory of experts are used instead.

Mean estimates of habitat factors are more likely to reflect the needs of those individuals within a population that provide the greatest reproductive contributions to the species. In contrast, providing only minimum habitat factors (e.g., snag size, canopy cover, proportion the landscape in a limiting vegetative structural stage) may cause a gradual decline in population abundance because of reduced reproductive success (Conner 1979). In this report, preference is given to summarizing data as estimates of population means (EPM) and associated 95 percent confidence intervals (*e.g., 24 in. ≤ population mean ≤ 30 in; to 95 percent standard of confidence assuming no bias*). In order to standardize data in the EPM and 95 percent confidence interval formats, some data cited from the literature have been mathematically manipulated. When available, data in this report are also reported as the results of "sample t tests" demonstrating statistically significant effects.

What is the status of goshawk population and distribution in California?

Although reported sightings provide limited inference on the distribution of goshawks in California, there is insufficient comprehensive information to gauge population trends in California. In particular, there is a lack of intensive goshawk survey data along the North Coast, and on private managed timberlands throughout the state.

Range:

The range of goshawks in California include the Sierra, Cascades, Klamath, Modoc and North Coast regions, as well as limited pockets in Southern California (Figure 1).

Figure 1:
Range of the northern goshawk (*Accipiter gentilis*) in California
(California Department of Fish and Game 1995)

Notes: Dark shading denotes summer range whereas
light shading denotes winter range.

Northern Goshawk Status Review Findings:

In 1998, the US Fish and Wildlife Service conducted an in depth status review for the goshawk in the western United States. The report provides summarized data on reported goshawk territories on public and private lands (Figure 2), and reported densities on public land (Figure 3).

Figure 2:
Reported goshawk territories in California per the US Fish and Wildlife Service (1998)

Region	Reported territories
Sierra Nevada/Cascades	
Federal lands/state parks	509
Private timberlands	49
Modoc Plateau	
Federal lands	59
Private/state timberlands	5
California Klamath	
Federal lands	130
Private/state timberlands	9
North Coast	
Federal lands	0
Private/state timberlands	7
Southern California	
Federal lands	2
Private timberlands	0
Central Coast	
Federal lands	0
Private timberlands	0
TOTAL	
Federal lands/state parks	700
Private/state timberlands	70

Notes: Source data are in Ch. 3, Pg. 87 of US Fish and Wildlife Service (1998).

Figure 3:
Reported densities of goshawk territories
for Forest Service units in northern California
with intensive goshawk inventory programs
(US Fish and Wildlife Service 1998)

Ranger District	National Forest	Reported territories (Post-1990)	Reported density
Goosenest	Klamath	34	1 / 2,185 acres
Almanor	Lassen	40	1 / 2,709 acres
McCloud	Trinity	24	1 / 2,894 acres
Beckwourth	Plumas	22	1 / 3,822 acres
Warner Mountain	Modoc	33	1 / 4,077 acres
Devil's Garden/Big Valley	Modoc	47	1 / 4,473 acres

Notes: Reported density was calculated as the number of recently active territories (i.e., reported as occupied at least once from 1990 to 1996) per area of forested habitat. However, it is unclear how the area of forested habitat is determined in relation to the area of surveyed territory. It is also unclear to what extent survey methods varied between ranger districts. **The answers to these questions could have implications on the appropriateness of comparing the reported densities listed above.**

In the Northern Goshawk Status Review, the US Fish and Wildlife Service (1998) notes that, "population data available to this Status Review are inadequate to allow determination of any current trends in goshawk populations in [California]. Territory data provided for this Status Review represent an accumulation of territory locations over time, and only small subsets of these territories have been monitored adequately to assess long-term occupancy." The report also notes that, "population studies on the Klamath National Forest; Goosenest Ranger District (Woodbridge and Detrich 1994, Detrich and Woodbridge 1994), and other monitoring efforts on National Forests (Lassen NF, Modoc NF), suggest that, while annual occupancy and reproductive success are highly variable, most known territories continue to be used by goshawks over a period of many years."

Based on its assessment of available information on the goshawk in California, the US Fish and Wildlife Service (1998) reached the following conclusions (Figure 4) regarding population status.

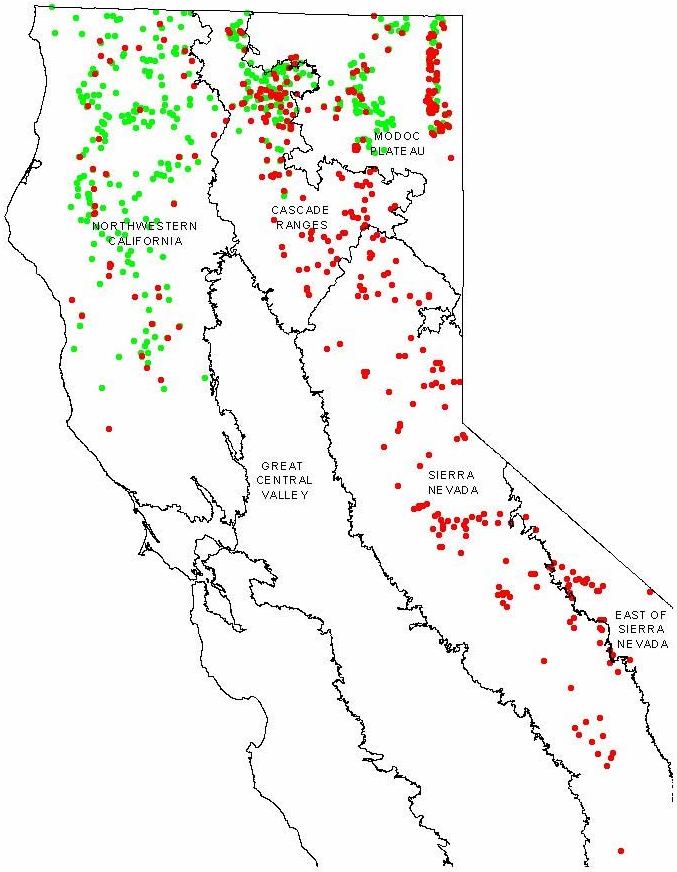
Figure 4:
US Fish and Wildlife Service (1998) conclusions regarding goshawk population status

1. Goshawks are well distributed and relatively abundant in most forested areas of the Sierra Nevada, Cascades, and Modoc Plateau in California.
2. Goshawks appear to be of limited distribution and rare in the North Coast and Southern California Provinces, and have not been reported to nest in the Central Coast Ranges.
3. Some reduction in historical goshawk populations likely resulted from large scale changes in amounts of mature forest habitat occurring from roughly 1850-1980.
4. Goshawk population data and habitat trend data available for this Status Review are not adequate to allow determination of current (post-1988) trends in goshawk populations in California.
5. Broad scale forest management planning efforts (Northwest Forest Plan, California Spotted Owl Interim Guidelines) and recent significant declines in timber harvest on Forest Service lands greatly increase the probability that future trends in mature forest habitat will be favorable for the goshawk over a significant portion of its range in California.
6. Although broad scale planning and land management efforts are likely to increase the overall abundance of mature forest habitat, current management guidelines aimed at maintaining goshawk territories are inadequate, often focuses on management of 5-50 acres surrounding the nest tree. Under current management practices, timber harvests may render many goshawk territories unsuitable for long term occupancy. If selection of nest areas by goshawks is based partially on physiographic location of landscape features, this may have a negative impact of goshawk populations.

Distribution on Private Timberlands:

In January 2001 (Figure 5) the Natural Diversity Database (NDDB, maintained by the DFG) contained 384 verified occurrences for goshawks. Most of these occurrences denote active or historical nest sites. The Forest Service has compiled a more comprehensive database for nest sites in northern California (Woodbridge 2001). This database includes points from NDDB and other sources.

Figure 5:
The distribution of 384 goshawk occurrences (red) from the January 2001 version of the Natural Diversity Database and 483 nest sites (green) from the Forest Service NCal Gos database



Coastal Status:

DeStefano and McCloskey (1997) suggest that, despite adequate prey populations, goshawk densities in the Oregon Coast Ranges are low because dense understory conditions limit goshawks' ability to hunt effectively. This theory may also explain the paucity of reported goshawk sightings along California's North Coast. According to the Northern Goshawk Status

Review (US Fish and Wildlife Service 1998), "several authors have suggested that under natural conditions, high vegetation density in mesic coastal forests provides poor quality habitat for goshawks, and that the species may naturally be rare in coastal habitats (Reynolds and Wright 1978, DeStefano and McCloskey 1997)."

There are approximately 30-40 reported sightings of goshawks in the northern California coastal range (Woodbridge 2000 personal communication). These sightings span Mendocino, Humboldt and eastern Trinity counties, appear to be concentrated to the east of the Redwood belt, and include a number of sightings in Six Rivers National Forest. In summary, there is insufficient data collected at this point to make any conclusions about the distribution and population trends of goshawks in the northern California coastal range.

What are the critical elements of goshawk autecology?

Movement:

In California, goshawks are resident or nomadic, not migratory (Woodbridge 2000 personal communication). The data collected by Richter and Callas (unpublished, Figure 6) show goshawks to wander further away from nest sites during winter months.

Figure 6:
Seasonal changes in the proximity of goshawks to a known nest
(Richter and Callas unpublished)

	Distance From Known Nest - miles		
	EPM (95%CI)	n	Sample range
Fall/winter	4.3 (2.4-6.1)	24	0.4-17.9
Spring/summer	10.3 (2.3-18.3)	10	0.8-44.5

Notes: Data are based on radio telemetry.

In California's Inyo National Forest, Hargis et al. (1994) noted a significant home range expansion after August 1 (i.e., one tailed paired sample t test, t=2.4, df=9, P=0.04).

Reproduction:

For the interior portions of California and the Southwest, goshawks generally begin courtship and mating in early March and remain together at the nest site until late August or September (Saunders 1982, Reynolds et al. 1992, Figure 7). Although there is a paucity of data for goshawks in the northern California coastal range (Harris 2000 personal communication), the nesting chronology occurs approximately one month earlier on the coast (Woodbridge 2000 personal communication).

Incubation generally occurs between April and May (Schnell 1958, Saunders 1982, Reynolds 1983, Bloom et al. 1985, Morrison 1992). The incubation period may be variable with the following values recorded: 30-32 days (Reynolds 1983); 36-38 days (Ehrlich et al. 1988); 36-41 days (Harrison 1978). In the interior portions of California, incubation regularly occurs through mid-June, with second attempts occasionally lasting into July (Keane 2000 personal communication). The nestling period has been recorded at 35-40 days (Kennedy 1989), 35-42 days (Ehrlich et al. 1988), 36 days (Reynolds 1983), 36-42 days (Boal 1994) and 40-45 days (Harrison 1978). Subsequently, the fledglings remain in the vicinity of the nest for an additional 30-60 days (Reynolds 1983, Kennedy 1989, Reynolds et al. 1992).

Figure 7:
Approximate goshawk nesting chronology in California

Activity	Approximate commencement date	Approximate completion date	Approximate duration of activity
Courtship/mating [1, 2]	March 1-15		
Incubation [1, 3, 4, 5, 6, 7, 8]	April 15 - May 15	May 15 - June 25	30-40 days
Nestling stage [4, 7, 8, 9, 10]	May 15 - June 25	June 20 - August 10	35-45 days
Post fledging [2, 9]	June 20 - August 10	July 20 - October 10	30-60 days

Notes: The timeline above was created by DFG staff by piecing together chronological data from a variety of sources. These sources are as follows: **1.** Saunders 1982; **2.** Reynolds et al. 1992; **3.** Schnell 1958; **4.** Reynolds 1983; **5.** Bloom et al. 1985; **6.** Morrison 1992; **7.** Ehrlich et al. 1988; **8.** Harrison 1978; **9.** Kennedy 1989; **10.** Boal 1994.

Feeding behavior:

Goshawks typically forage by perching on a branch or snag for a short period of time, waiting and searching for prey, and then taking a short flight to the next perch to repeat the process (Kenward, 1982, Widen 1985, Reynolds et al. 1992, Bosakowski 1999). Goshawks rarely attack prey spotted while in flight. However, because of a short wingspan, goshawks are well suited to maneuvering through dense forest in pursuit of prey once spotted (Bosakowski 1999). Emerging from cover in the lower forest canopy, a goshawk ambushes it prey either by swooping silently down from behind into small openings (Schnell 1958, Beebe 1974, Johnsgard 1990) or by crashing down "recklessly" through layers of branches and shrubs (Beebe 1976, Bosakowski 1999). Goshawks may also startle birds, such as wood pigeons and grouse, capturing them after a rapid flight chase (Kenward 1978). Alternatively, by hopping along the ground, or from branch to branch, a goshawk sometimes captures prey by means of prolonged but persistent chases (Westcott 1964, Bergstom 1985, Bosakowski 1999).

Goshawks are opportunistic foragers with diets reflecting the local availability of prey species (Opdam 1975, Widen 1987, Kenward and Widen 1989, Kennedy 1991, Boal and

Mannam 1994). Bloom et al. (1985) surveyed prey remains at 114 active goshawk territories in California between 1981 and 1983, and his data suggest that the most important goshawk prey species in California is Douglas' squirrel (*Tamiasciurus douglasii*), and that lagomorphs, golden mantled squirrel (*Spermophilus lateralis*), Steller's jay (*Cyanocitta stelleri*), blue grouse (*Dendragapus obscurus*), northern flicker (*Colaptes auratus*), western grey squirrel (*Sciurus griseus*) and American robin (*Turdus migratorious*) are also quite important (Figure 8). Schnell (1958) and Woodbridge et al. (1988) have reported a similar mix of goshawk prey species in California. However, on an industrial forest in western Washington, Bosakowski et al. (1999) found a much higher consumption of grouse compared to studies in northwest national forests, where goshawks relied primarily on forest interior prey species (Reynolds and Meslow 1984, Bull and Hohmann 1994). In northern California, McCoy (2000) found goshawks to prey mostly on small mammals, especially golden-mantled ground squirrels and Douglas' squirrels, although birds were preyed upon as well, especially jays and woodpeckers.

Figure 8:
11 species with the most abundant prey remains surveyed at nest sites of goshawks in California (Bloom et al. 1985)

Species	Importance rank	% of individuals	% of biomass
Douglas' squirrel	**100**	21	14
unidentified lagomorph	**51**	2	16
golden-mantled ground squirrel	**49**	9	8
Steller's jay	**46**	12	4
blue grouse	**34**	3	9
northern flicker	**29**	7	3
western gray squirrel	**29**	7	3
northern flying squirrel	**26**	6	3
snowshoe hare	**20**	1	6
American robin	**17**	5	1
white-tailed hare	**17**	<1	6
unidentified passerine	**14**	5	<1

Importance rank was not part of the Bloom et al. (1985) study. This metric has been created by DFG staff to assess the relative importance of goshawk prey species in California. It is calculated by multiplying the sum of the two percentages featured in the table above by a normalization factor of 2.86.

Additional Notes: Bloom et al. (1985) surveyed prey remains at 114 active goshawk nest sites throughout California between 1981 and 1983. The scientific names for snowshoe hare and white-tailed hare are *lepus americanus* and *lepus townsendii*, repectively.

The preponderance of evidence suggests that goshawks prefer to forage within forest cover (Fischer 1986, Widen 1989, Reynolds et al. 1992, Austin 1993, Doyle and Smith 1994, Hargis et al. 1994, Bright-Smith and Mannan 1994). Research results from northern Arizona (Brier and Drennan 1997) show that goshawks more often select foraging sites within forest cover even when prey are more abundant elsewhere within the home range. Goshawks also hunt from cover along edge habitats (Shuster 1980, Younk and Bechard 1992, Graham et al.1994).

What are the critical elements of goshawk prey species ecology?

An analysis of California Wildlife Habitat Relationship System (CWHR, Figure 9) data suggests that multi-strata forest cover (i.e., subcanopy trees greater than 10 percent cover) is the most important habitat element for the most common goshawk prey species in California. Conifers, herbaceous and shrub layers, tree leaves, terrestrial insects, invertebrates, grasses, seeds, trees with cavities and snags are also important habitat elements for these prey species. In Arizona, an analysis by Reynolds et al.(1992, Figure 25) suggests that large trees, herbaceous/shrub understories and the interspersion of habitat types are the 3 most important habitat characteristics for 14 goshawk prey species (i.e., high or medium habitat characteristic importance level, total of 8 listed characteristics) whereas openings greater than 4 acres was the characteristic of least importance.

Figure 9:
Critical habitat elements for 11 goshawk prey species
per the California Wildlife Habitat Relationships System

Prey species (modified importance rank)	Essential element	Secondarily essential element
Douglas' squirrel (100)	Layer, tree	Fungi Seeds Trees, pine Trees, with cavities Snag, large
Golden mantled ground squirrel (49)	none	None

Steller's jay (46)	none	Seeds Fruits Invertebrates Insects, terrestrial Insects, flying Layer, tree Layer, shrub Trees, pine Trees, fir
Snowshoe hare (46)	Graminoids Tree leaves	Forbs Shrubs Layer, tree Layer, shrub Layer, herbaceous Riparian inclusion Tree/shrub Tree/grass Shrub/grass
White-tailed hare (43)	Layer, herbaceous	Graminoids Forbs Shrubs Layer, shrub Layer, herbaceous
Blue grouse (34)	Tree leaves Trees, fir	Insects, terrestrial Layer, tree Layer, shrub Layer, herbaceous Trees, fir Tree/shrub Shrub/grass Shrub/water Grass/water
Northern flicker (29)	Insects, terrestrial Invertebrates	Snags, small Snags, medium Snags, large Layer, tree Trees, with cavities

Western gray squirrel (29)	Layer, tree Trees, fir	Fungi Graminoids Forbs Acorns Trees, pine Trees, hardwood Water
Northern flying squirrel (26)	Lichens; Layer, tree Trees, with cavities	None
American robin (17)	Invertebrates	Insects, terrestrial Insects, flying Layer, shrub Trees, hardwood Trees, pine Trees, fir Layer, trees
Red-breasted nuthatch (14)	Invertebrates Insects, terrestrial	Seeds Layer, tree Trees, with cavities Snags, medium Snags, large Stumps Snags, small

Habitat element rank	Importance	CWHR definition
Layer, tree	**100**	subcanopy trees greater than 10 percent cover
Trees, fir	**44**	trees of the genus *Abies* with dbh greater than 11 inches
Layer, herbaceous	**39**	subcanopy herbaceous vegetation greater than 10 percent cover
Tree leaves	**37**	leaves (and/or new stem production) of trees
Insects, terrestrial	**35**	fed upon while not on or under water or in the air
Invertebrates	**35**	animals without a backbone, in general
Trees, with cavities	**34**	trees possessing one or more cavities
Graminoids	**32**	grasses and grass-like plants
Trees, pine	**29**	trees of the genus *Pinus* with dbh greater than 11 inches.
Layer, shrub	**29**	subcanopy shrubs greater than 10 percent cover
Seeds	**25**	ripened ovules of flowering plants exclusive of other seed elements

Snags, large	22	greater than 30 inches dbh
Fungi	20	saprophitic spore-forming, non-vascular plants such as mushrooms, molds, etc.
Forbs	18	herbaceous dicotyledonous plants
Shrubs	14	woody plants of smaller stature than trees when fully grown
Shrub/grass	12	transition between any stand of trees, size class 2 or any stand of shrubs classes 2, 3, or 4, **and** any herbaceous stand, or any stand of trees or shrubs class 1
Tree/shrub	12	transition between any stand of trees, size class 3, 4, 5, or 6 **and** tree size class 2, or shrub classes 2, 3, or 4
Lichens	12	algal-fungal symbiotic associations on solid surfaces
Insects, flying	10	fed upon in the air
Fruits	7	pulpy fruit reproductive body of a seed plant
Riparian inclusion	7	small (not mappable) stand of vegetation which is associated with permanent water, includes seeps
Tree/grass	7	transition between any stand of trees, size class 3, 4, 5, or 6 **and** tree or shrub classes 1, or any herbaceous stand
Trees, hardwood	7	hardwood trees with dbh greater than 11 inches dbh
Snags, medium	7	between 15 and 30 inches dbh
Snags, small	7	less than 15 inches dbh
Grass/water	5	transition between any herbaceous stand **and** any wetland or aquatic habitat
Shrub/water	5	transition between any stand of shrubs, classes 2, 3, or 4 **and** any wetland or aquatic type
Acorns	4	fruit of an oak
Water	4	any source of free water
Stumps	2	any snag less than 10 feet in height

Notes: Per CHWR, an essential element is an element that must be present within the home range of a species for the species to be present, whereas a secondarily essential element is an element that must be present withing a home range of the species for the species to be present unless it is compensated by the presence of another secondarily essential element that serves the same function to the species. The modified importance rank for prey species has been created by DFG staff by taking the importance rank from Figure 8 and splitting the points from the unidentified lagomorph between snowshoe hare and white-tailed hare. Red-breasted nuthatch (*sitta canadensis*) has been selected to represent the unidentified passerine from Figure 8. The importance rank for each habitat element was calculated by adding 3 points every time an essential element was listed, adding 1 point each time a secondarily essential element was listed, and dividing the sum by a normalization factor of 6.51.

What are the habitat elements required by goshawks at different life cycle stages?

Nest Tree:

Goshawks select nest trees that have a combination of features (e.g., nest platform, access, height of bottom of live crown). In interior portions of northern California, goshawks frequently use these nesting features by selecting either one of the largest live trees in a stand or a smaller live deformed tree.

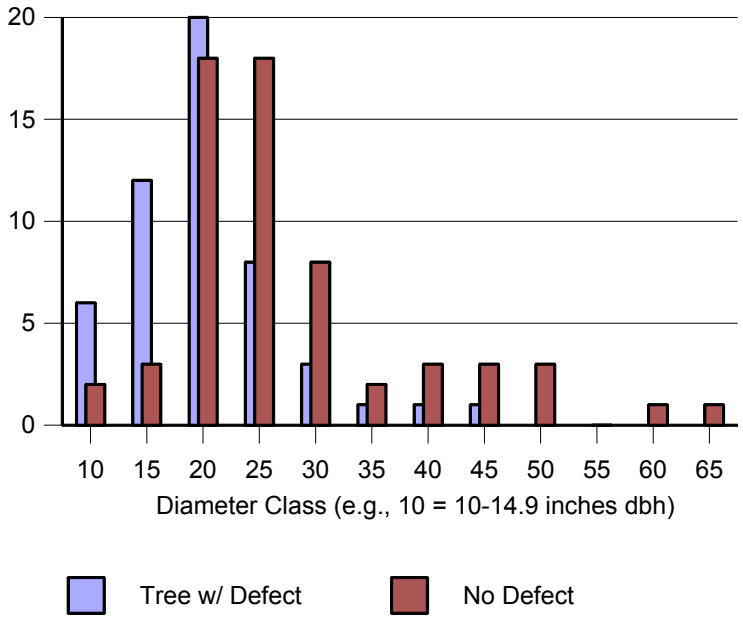
Within stands, goshawks often select one of the largest trees for nesting (Bent 1937, Reynolds et al. 1982, Saunders 1982, Hall 1984, Erickson 1987, Hargis et al. 1994, Ingraldi and McVean 1995, Squires and Ruggiero 1996). On the Shasta Trinity National Forest, Saunders (1982) found that mean diameter of nest trees was 29 inches, almost three times higher than the 10.7 inch mean diameter of all trees in nest stands. By statistically pooling (as separate strata) the data from four studies conducted in the interior portions of northern California and eastern Oregon, DFG staff estimate the population mean diameter of nest trees to be between 24 and 30 inches dbh at the 95 percent confidence level (Figures 10 and 11). In northern California, 91% of the nests monitored by Richter and Callas (2000) were in live trees.

Figure 10:
Estimates of average goshawk nest tree diameters (dbh-in.)
in California and eastern Oregon

Study	Location	EPM (95%CI)	n	Sample range
Pooled Data		**27 (24-30)**	**162**	
Farber et al. 1998	northern CA(interior)	25 (22-28)	87	10-79
Richter & Callas 2000	northern CA(interior)	26 (24-28)	127	11-84
Saunders 1982	Shasta Trinity NF	29 (24-35)	13	17-48
Hargis 1994	Inyo NF	35 (32-39)	10	
Bull & Hohnmann 1994	northeastern Oregon	26 (21-31)	12	

Notes: Farber et al. (1998) data not included in pooled data analysis because of duplication of sites with Richter and Callas 2000. EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

Figure 11:
The diameter distribution of trees used by goshawks for nesting
in northern California (Richter and Callas 2000)



Goshawks typically locate their nests at the base of the live canopy where flight access through the forest is facilitated (Shuster 1980, Reynolds et al. 1982, Moore and Henry 1983, Spieser and Bosakowski 1987, Richter and Callas 2000). Fleming (1987) suggested that, in young pole sized stands, the hawks resort to locating their nests in mistletoe afflicted or deformed trees because of the lack of large branches needed for nest support. In corroboration of this finding, the northern California data of Richter and Callas (2000, Figures 11 and 13) provide evidence of a relationship between nest trees defect and diameter. Richter and Callas (2000, Figure 12) provide the following additional data on nest tree parameters.

Figure 12:
Estimates of other goshawk nest tree parameters in northern California (Richter and Callas 2000)

Parameter	Sample median	EPM (95% CI)	n	Sample range
Nest tree DBH (in)	23	26 (24-28)	127	11-84
Nest tree height (ft)	105	108 (102-113)	125	40-217
Nest height (ft)	55	59 (56-62)	125	28-111

Notes: EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

Figure 13:
The relationship between defect and the diameters of trees used by goshawks for nesting

	Diameter at Breast Height in Inches				
Defect	Sample median	EPM (95%CI)	n	% below 20"	% below 24"
Yes	22	22.5 (20.6-24.3)	52	34.6	67.3
No	27	29.6 (26.9-32.3)	62	8.1	32.3

Notes: This relationship is based on an analysis of the data collected by Richter and Callas (2000). Defect has been stratified for live nest trees only, and includes nest placement at crooks, broken tops, multiple tops, crotches & mistletoe brooms. EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

Nest Area and Nest Stand Cluster:

Reynolds (1983) defines the nest area as the 20 to 25-acre area around the nest; this area is identified as a patch of dense, larger trees and contains prey plucking and perch sites. Other authors corroborate the observation that goshawks tend to locate nesting sites within patches of forest that are older, more mature and have higher canopy cover than random sites (Hall 1984, Spieser and Bosakowski 1987, Squires and Ruggiero 1996, Figure 14). McGrath (1997) found that goshawks select nest sites with higher canopy cover and basal area at a minimum scale of 25 acres, whereas Desimone (1997) found non-randomness for the same features out to 130 acres.

On managed timberlands in northern California, 4M, 4D, 5M, 5D or 6 accounted for the CWHR habitat type 68.4 percent of the time for known goshawk nest areas at the 25-acre scale (Figure 14)

Figure 14
Comparison of habitat conditions at known goshawk nest sites with the conditions in the surrounding forest (Richter and Callas 2000*, Farber et al. 1998)**

	Percent of Each Nest-centered Circle by CWHR Type				
CWHR Class	0.1-acre* (n=122)	2.5-acre** (n=30)	25-acre** (n=29)	205-acre** (n=27)	420-acre** (n=29)
3	1.6	10.0	11.3	7.6	8.0
4M	9.0	9.4	20.6	32.7	32.8
4D	52.5	44.6	34.3	25.9	22.5
5M	0	0	0	0.4	0.3
5D	0.8	5.7	4.0	1.5	0.8
6	32.8	18.1	12.9	7.9	7.0

Notes: CWHR denotes California Wildlife Habitat Relationships. CWHR categories are as follows: **3** denotes stand quadratic mean diameter (QMD) between 6 and 11 inches, **4** denotes stand QMD between 12 and 24 inches, **5** denotes stand QMD above 24 inches, **6** denotes a distinct layer of 5 over 4 or 3, **M** denotes stand canopy closure between 40 and 60 percent, **D** denotes stand canopy closure above 60 percent.

Within a single territory, there are usually several alternative nests that are used by goshawk pairs over several years (Reynolds and Wright 1978, Speiser and Bosakowki 1987, Reynolds et al. 1994, Woodbridge and Detrich 1994, Reynolds and Joy 1998). Woodbridge and Detrich (1994) focus on the concept of a nest stand cluster defined as the aggregate area of all stands containing the alternate nest trees within a territory. In the southern Cascades of California, these researchers found the following characteristics for nest stand clusters (Figure 15).

Figure 15:
Estimates of average characteristics for goshawk nest stand clusters in the southern Cascades of California (Woodbridge and Detrich 1994)

Characteristic	EPM (95%CI)	n	Sample range
Alternate nest sites (#)	2.4 (2.2-2.6)	71	1-5
Distance between sites (ft)	896 (841-951)	65	98-6,778
Nest stand size (acres)	69 (66-72)	71	10-284
Nest stand cluster size (acres)	103 (97-109)	26	26-282

Notes: EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM. Nest stands were defined as patches of forest that were homogenous in composition, age, and structure relative to the surrounding forest and were used for nesting. Nest stand clusters were defined as the aggregate area of all stands within a territory that were used for nesting.

Farber et al. (1998) provide the following data (Figure 16a) on northern California nest stand habitat conditions. Despite the absence of statistical qualifiers, these data suggest that goshawks select nest sites with higher tree densities and larger trees. However, these conditions appear highest near the nest and "feather out" to smaller diameter/lower density forest as the distance from the nest increases.

Figure 16a:
Characteristics of goshawk nest area for plots centered on known nests on California industrial timberlands (Farber et al. 1998)

Sample Means (Sample Sizes)

Parameter	0.1-acre scale	2.5-acre scale	25-acre scale
Basal Area (ft^2)	274.5 (n=42)	215.3 (n=56)	172.2 (n=13)
QMD (in.)	18.4 (n=53)	17.0 (n=56)	12.2 (n=13)
TPA > 5 in.	173.1 (n=42)	157.5 (n=56)	n/a
TPA > 22 in.	38.1 (n=19)	25.7 (n=61)	16.1 (n=13)

Notes: No information provided on the statistical variance of these data. QMD denotes quadratic mean diameter at breast height. TPA denotes trees per acre.

Analysis of habitat conditions around nest sites undertaken by Daw and DeStefano (2001) provides insight into what the significant scale is at which habitat around nests differs from conditions available in the larger landscape (Figure 16b). By comparing conditions within concentric circles around nests with concentric circles around random areas, these researchers demonstrated the occurrence of significantly more dense, late seral forest structure around nests at the 30 and 60 acre scales. This trend continued at the 125 acre scale, but diminished for larger scales.

Figure 16b:
The scale at which habitat around goshawk nests differs from landscape conditions, Malheur National Forest, Oregon (Daw and DeStefano 2001)

P-values (area in dense canopy, late seral forest structure[1] around nests versus around contrast random contrast points)

Scale	versus random points[2]	versus non-nesting random points[3]
30 acres	0.031	0.050
60 acres	0.061	0.081
125 acres	0.114	0.107
300 acres.	0.279	0.210
420 acres	0.441	0.437

Notes:
1. Dense canopy, late seral forest structure defined as trees greater than 20 inches dbh and canopy greater than 50 percent.
2. The first set of random points represents available forest.
3. The second set of random points represents areas not used by nesting goshawks.

Richter and Callas (2000) provide the following additional data (Figure 17) with a larger sample size and statistics, for 0.1 acre plots around the nest tree, including many of the same sites observed in the Farber et al. (1998) study. The data below suggest that, near the immediate nest site, high canopy closure is an important factor. Other researchers have shown that canopy closure at nest sites is significantly higher than at random sites (Crocker-Bedford and Chaney 1988, Schaffer 1998). Further evidence suggests that a dense canopy is important for insolation (Reynolds et al. 1982, Hall 1984) and providing concealment from aerial predators and nest robbers including great horned owls, red tailed hawks and corvids (Moore and Henry 1983, Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990).

Figure 17:
Estimates of goshawk nest site parameters
for 0.1-acre plots centered on the nest (Richter and Callas 2000)

Parameter	Sample Median	EPM (95% CI)	n	Sample range
Slope (%)	15	19 (17-22)	122	0-60
Canopy closure (%)	91	84 (81-88)	118	25-100
Trees/0.1 acre	35	45 (39-51)	120	9-160

Notes: QMD denotes quadratic mean diameter at breast height. EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

Goshawks often nest near water (Bond 1942, Beebe 1974, Shuster 1980, Reynolds et al. 1982, Hargis et al. 1994). However, goshawks are also found nesting in places far from water sources (Woodbridge 2000 personal communication). During a study of goshawks in California's Inyo National Forest, Hargis et al. (1994) found a significant difference between the distance from nests to nearest water sources and random sites to nearest water sources (Figure 18).

Figure 18:
An estimate of mean distance from goshawk nests
on the Inyo National Forest to water sources (Hargis et al. 1994)

EPM (95% CI)	n	P value (for comparison with random sites)
0.75 miles (0.52-0.98)	10	0.06

Notes: EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM. The P value is for a one tailed paired sample t test comparing the distances between nest sites and nearest water sources with the distances between random sites and the nearest water sources.

Goshawks often nest close to forest openings such as meadows, clearings, logging trails, dirt roads and fallen trees (Gromme 1935, Reynolds et al. 1982, Hall 1984, Erickson 1987, Hayward and Escano 1989). These openings may serve as travel corridors and facilitate access to the nest (Erickson 1987, Speiser and Bosakowski 1987). One California study found that goshawks nested an average of 279 feet from medium-use roads (Saunders 1982).

Goshawks use snags, logs, stumps, old nests, and low, bent-over trees of saplings for plucking prey in nest areas (Schnell 1958, Palmer 1988, Keane 2000 personal communication). In California, Hall (1984) found an average of two plucking perches per nest site, and Schnell (1958) and Bull and Hohmann (1994) provide the data featured below on distances between plucking perches (Figure 19). In Arizona, Reynolds et al. (1982) found the mean distance between the nest and plucking perches to be 148 feet.

Figure 19:
Distances between goshawk plucking perches in two California studies

Study	Location	Sample mean	n	Sample range
Pooled Data		**158 ft.**	**56**	**23-425**
Schnell 1958	Lake Tahoe, CA	226 ft.	13	98-425
Bull and Hohmann 1994	northeastern Oregon	138 ft.	43	23-656

Notes: No information provided on the statistical variance of these data.

Post-fledging Area:

The Post-fledging area (PFA) has been estimated to average 420 acres in size, varying between 300 and 600 acres (Kennedy 1989). Spatial use of the PFA changes over time as juveniles wander farther away from the nest (Figure 20). A DFG analysis (Figures 20 and 21) of the data provided by Kennedy et al. (1994) and Shipman (1999) shows that over 90 percent of juvenile sightings up to 6 weeks after dispersal from the nest were within 1,312 feet (400 m) of the nest; this corresponds to a radial area of 124 acres. About 70 percent of sightings up to 6 weeks after dispersal were within 656 feet, an area corresponding to 31 acres.

Figure 20:
The changing spatial pattern of use of the post flegling area over time in one New Mexico study (Kennedy et al. 1994)

Weeks after dispersal from nest	1	2	3	4	5	6	7	8
Mean distance of juveniles from nest (ft)	39	156	165	540	991	1,797	4,366	6,416
Associated radial area (acres)	0.1	1.7	2.0	21	71	233	1,373	2,967

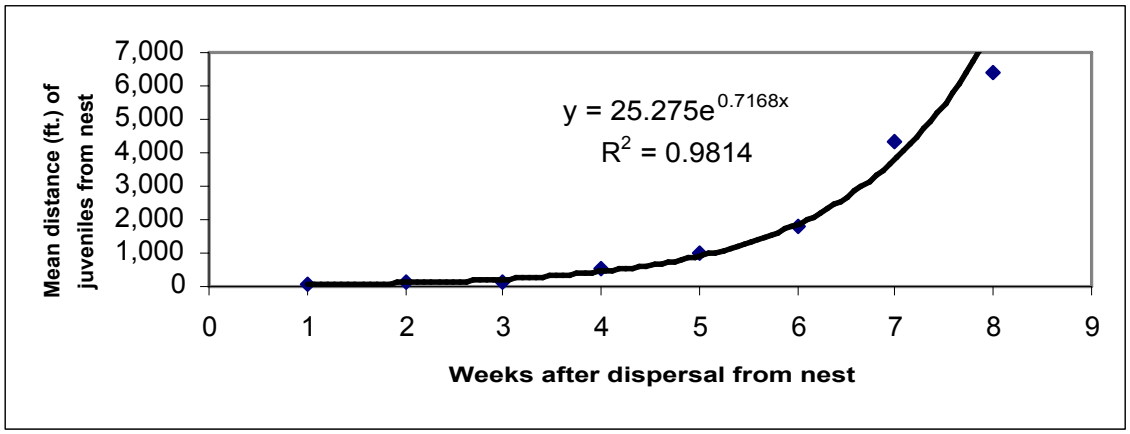


Figure 21:
Observations of juvenile dispersal during the first six weeks post fledging
(Kennedy et al. 1994, Shipman 2000)

	Sample Size		Percent of Observations Made Within Given Distances (Areas) From The Nest			
Study	# of observations	# of broods	328 feet (8 acres)	656 feet (31 acres)	1,312 feet (124 acres)	2,624 feet (497 acres)
Pooled data		**23**	**47 %**	**72 %**	**91 %**	**97 %**
Kennedy et al. 1994 (New Mexico)	263	15	54 %	74 %	91 %	95 %
Shipman 1999 (Nevada)	399	8	34 %	68 %	92 %	100 %

Notes: Data pooled statistically by averages weighted by "# of broods."

The PFA surrounds the nest site and is used by the juvenile birds to learn to hunt and fend for themselves. It contains a mosaic of large trees, large snags, mid-aged forests, small openings with a herbaceous understory, and large downed logs (Graham et al. 1994). These elements may be important for the juveniles and their prey, as several authors (Reynolds et al. 1992, Kennedy et al. 1994, Graham et al. 1994) reason that the PFA provides concealment from predators, high prey availability, and an area to develop hunting skills. The 25 and 205-acre area classes used in the Farber et al. (1998, Figure 13) study most closely correspond to the most intensively used core of the PFA (Kennedy et al. 1994, Shipman 1999, Figure 21), and CWHR habitat types at these scales have been classified as 4M, 4D, 5M, 5D or 6 for between 68.4 and 71.8 percent of observed territories (Farber et al.1998, Figure 14).

Foraging/Home Range:

Throughout North America home ranges vary between 1,200 and 10,000 acres in size (US Fish and Wildlife Service 1998). In the southern Cascades of California, Austin (1993) used the minimum convex polygon method to calculate a mean home range size of 7,660 acres. In eastern California, Hargis et al. (1994) found that radio tagged goshawks had a mean range of 3,830 acres (Figure 22). Although the variability of individual home ranges is high for both studies, females tended to have larger ranges than males and winter ranges tended to be larger than summer ranges.

Figure 22:
Estimates of average goshawk home range sizes in California

		Size in acres	
Study	Location	EPM (95% CI)	n
Pooled Data		**5,745 (3,229-8,261)**	**20**
Austin (1993)	Southern Cascades	7,909 (4,079-11,739)	10
Hargis et al. (1994)	Southeastern Sierra	3,830 (2,467-5,192)	10

Notes: EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

On the Inyo National Forest, Hargis et al. (1994) found a statistically significant correlation in association with home ranges as compared to random control sites. These were related to: (1) higher basal area, (2) increased canopy cover, (3) higher density of trees greater than 24 inches dbh, (4) higher density of trees 18-24 inches dbh, and (4) higher density of trees 6-11 inches dbh. This researcher also found an apparent trend toward greater diversity of vegetative types per square kilometer within home ranges as compared to random control areas.

Based on the relative importance of 6 different vegetative structural stages in providing habitat to 14 goshawk prey species, Reynolds et al. (1992) recommend desired conditions for goshawk home ranges in southwestern ponderosa pine, mixed species and spruce-fir forests (Figure 23).

Figure 23:
Recommended distribution of vegetative structural stages within home ranges on Forest Service land in the southwestern United States (Reynolds et al. 1992)

Veg.Struct.Stage	Dbh Range	Desired Proportion
grass/forb/shrub	0-1"	10%
seeedling/sapling	1-5"	10%
young forest	5-12"	20%
mid-aged forest	12-18"	20%
mature forest	18-24"	20%
old forest	24"+	20%

Notes: These recommendations were based on an analysis (Figure 26) of the habitat requirements of 14 goshawk prey species.

For foraging sites, Brier and Drennan (1997) found a higher level of correlation with habitat structure than with prey abundance (Figure 24). Compared to contrast plots, they found that goshawks selected foraging sites that had higher canopy closure, greater tree density, and more trees greater than 16 inches dbh. Haris et al. (1994, Figure 25) also note a correlation between goshawk foraging ranges and habitat structure.

Figure 24:
Habitat characteristics of sites selected by goshawks for foraging in a study on the Kaibab National Forest (Brier and Drennan 1997)

Characteristic	Plots used for foraging	Random contrast plots	P value
Canopy closure (%)	48.3	43.1	0.006
Tree density (trees per acre > 4" dbh)	248	193	0.001
Large trees (trees per acre >16" dbh)	21	12	<0.0005

Notes: The study followed the foraging behavior of 20 radio tagged goshawks on the Kaibab National Forest in Arizona. The "P" value is for a two-tailed paired sample t test (15 degrees of freedom) of the null hypothesis that the mean difference is zero.

Figure 25:
The correlation between various habitat characteristics and goshawk home ranges on the Inyo National Forest (Hargis et al. 1994)

	EPM (95% CI)	P value (for comparison with random plots)
Basal area (sq. ft./ac.)	170 (138-202)	< 0.01
Canopy cover (%)	34 (24-44)	< 0.01
Trees per acre 18-24 in. dbh	0.69 (0.32-1.07)	< 0.01
Trees per acre > 24 in. dbh	0.49 (0.19-0.79)	< 0.01

In an attempt to assess the habitat requirements of goshawk prey species, DFG staff have used CWHR data to prioritize the relative importance numerous habitat elements to 11 prey species. The results of this analysis suggest (Figure 9) that multi-strata forest cover (i.e., subcanopy trees greater than 10 percent cover) is the element of overiding importance for prey species, and that confiers, herbaceous and shrub layers, tree leaves, terrestrial insects, invertebrates, trees with cavities, grasses, and seeds are also very important. In a study of the relative importance of habitat characteristics to 14 goshawk prey species in Arizona, Reynolds et al. (1992, Figure 26) determined that large trees, understory and shrub development, and the interspersion of vegetative structural stages are the most important characteristics for maintaining high and medium populations of prey. Additionally, hypogeous fungi are an important food source for goshawk prey (e.g., squirrels), and play a symbiotic role in the maintenance of forest vegetation (Graham et al. 1994).

Figure 26:
The relative importance of 8 habitat characteristics
for 14 goshawk prey species (Reynolds et al. 1992)

	Number of Species for Each Importance Level			
	High	Medium	Low	Not important
Logs	4	5	2	3
Woody Debris	3	4	6	1
Openings < 4 acres	3	4	1	6
Openings > 4 acres	1	2	1	10
Snags	5	1	6	2
Large Trees	7	5	1	1
Herb Shrub Understory	6	5	2	1
Interspersion	5	6	3	0

Notes: The 14 prey species are: American robin, band-tailed pigeon (*Columba fasciata*), blue grouse, chipmunks, cottontails, hairy woodpecker (*Picoides villosus*), golden mantled ground squirrel, mourning dove (*Zenaida macroura*), northern flicker, red-naped sapsucker (*Sphyrapicus nuchalis*), red squirrel, Steller's jay, tassel-eared squirrel and Williamson's sapsucker *(Sphyrapicusthyroideus*). Definitions of the 8 habitat characteristics are as follows: snags >18" dbh & 30' high; downed logs >12" diameter & 8' long; woody debris > 3' diameter; large trees > 18" dbh, live; understory is presence of herbaceous and shrubby species; interspersion is the degree of intermixing of vegetative structural stages on the scale of prey species.

Small and medium sized forest openings (i.e., less than 4 acres) probably enhance the availability of prey, whereas larger openings are of less use to the majority of goshawk prey species (Reynolds et al. 1992, Figure 26).

In lethal fire regimes (e.g., interior true fir and Douglas-fir forests), where larger openings are created, goshawks require larger home ranges, because they primarily utilize the edges of openings for foraging. The interspersion of different seral stages is also reduced in lethal fire regimes (Graham et al. 1995). On the other hand, nonlethal fire regimes regularly clean out understories in Ponderosa pine forests, creating excellent foraging habitat for goshawks (Graham et al. 1995), because open understories enhance the detection of prey (Spieser and Bosakowki 1987, Crocker-Bedford 1990, Reynolds et al.1992).

How does forest management affect goshawks?

Some literature supports the idea that timber harvesting adversely impacts goshawk nesting habitat (Hennessy 1978, Reynolds et al. 1982, Moore and Henry 1983, Crocker-Bedford 1990, Woodbridge and Detrich 1994, Bright-Smith and Mannan 1994, Beier and Drennan 1997, Desimone 1997). In particular, Crocker-Bedford (1990) attributed a 94 percent drop in "nestling

production" to logging. This study notes that timber harvesting had negative impacts on goshawks in three ways: (1) structural changes impairing hunting ability of goshawks (e.g., succession to heavy understory, shrub cover); (2) decreases in prey abundance; and (3) competition from invasion of open country raptors (red-tailed hawk, great horned owl). Based on an analysis of canopy closure within home ranges in northern Arizona, Bright-Smith and Mannan (1994) note that timber harvesting that creates large areas with sparse tree cover may be potentially detrimental to goshawks, especially if the percent of open forests (e.g., 34 percent canopy cover in their study) in a home range is greater than 35 percent.

Some literature supports the idea that past forest management has not adversely affected goshawk populations, and that some forest management activities may improve goshawk habitat. On the Goosenest Ranger District of the Klamath National Forest, Woodbrdige and Detrich (1994) used intensive surveying to measure fairly high territory densities of 1 / 2,309 acres in "Sierra montane forest" (n=11) and 1 / 4,297 acres in "upper montane forest" (n=10). Furthermore, these researchers found no significant relationship between nest stand cluster size and productivity (r_s=0.052, P=0.819). Similarly, Patla (1997) found no significant difference in productivity between pre and post harvest territories in Idaho (n=10). Several authors note that forest management practices such as the use of controlled burning and mechanical thinning from below may improve habitat conditions for goshawk by opening up dense understory vegetation that has built up as a result of decades of fire suppression (Reynolds et al. 1992, Graham et al. 1995, Farber et al. 1998).

Figure 27:
The relationship between nest stand cluster size
and the annual occupancy of nests within these clusters
(Woodbridge and Detrich 1994)

Stand cluster size	Occupancy
Less than 50 acres	less than 50%
100 acres	75-80%
Greater than 150 acres	almost 100%

Positive correlation between stand cluster size and occupancy: P =0.008, r_s = 0.052

Notes: Nest stand cluster size was determined as the aggregate area of all stands within a territory that were used for nesting. The occupancy rate for each cluster was calculated by dividing the number of years the cluster was occupied by the total number of years the cluster was monitored. The clusters in the correlation include 23 of the 26 clusters from the study with at least five years of monitoring data.

The following quotation from Woodbridge and Detrich (1994) presents a possible relationship between goshawk territories and timber harvesting: "Despite intensive timber harvest and fragmentation of mature forest, our study area supported high densities of nesting goshawks. Goshawk territories, however, were associated with the larger remaining patches of mature forest, and territory occupancy was positively correlated with the size of nesting habitat patches." Fugure 27 provides more detail on the correlation noted by Woodbridge and Detrich (1994). Patla (1997) also observed that goshawk territories are often associated with larger remnant patches of mature forest, and she found a strong correlation between occupied nest stand clusters and mature forest cover. For California territories with nest buffers of 5-20 acres, Richter and Callas (2000) found a 47 percent occupancy rate for the potential occupancy years (n=212). This occupancy rate is similar to the findings of Woodbridge and Detrich (1994) as outlined in Figure 27, and may show the impacts of forest fragmentation on territory occupancy.

Considering the importance of defective trees for goshawks and their prey, sanitation and salvage silviculture may reduce the quality of nesting and foraging habitat (Saunders 1982, Richter and Callas 2000).

Noise and disruption associated with timber harvest operations (e.g., harvesting, log truck traffic, road construction, timber cruising) can cause nest failure, especially during pair bonding, nest-building and incubation (Anonymous 1989, US Forest Service 1992, Boal and Mannan 1994, Squires and Reynolds 1997). Hennessy (1978, Figure 28) found that, of three accipiter species studied within the Cache National Forest of Utah and Idaho, goshawks "showed the greatest preference for isolation from man," nesting farther from human disturbance, farther into cover and with more horizontal visibility from the nest than the other accipiters.

Figure 28:
Estimates of average distances from goshawk nests in Idaho to habitat edges and areas of human disturbance (Hennessy 1978)

	EPM (95%CI)	n	Associated area
Nest distance to cover edge	186 feet (106-266)	25	2.2 acres (0.8 - 5.1)
Horizontal visibility in nest area	153 feet (129-177)	25	0.45 acres (0.3 - 0.6)
Nest site to human disturbance	832 feet (541-1,123)	25	56 acres (21 - 91)

Notes: EPM denotes the estimate of the population mean and 95%CI denotes the 95% confidence interval for the EPM.

Considering goshawks' preference for hunting within forests and along edges, landscape shifts to a catastrophic fire regime, and from uneven-aged to even-aged management, may decrease the amount of available foraging habitat. For example, Graham et al. (1995) state that less than 10 acres along the edge of a 25-acre opening was used by goshawks for foraging.

An analysis of Landsat-derived habitat conditions in 125-acre circles around 117 goshawk nests in northern California has demonstrated the occurrence of significantly more large

trees and greater canopy closure with respect to conditions around randomly located points. The Interior Timberland Planning team of the DFG's Northern California -North Coast Region has used this analysis to support a risk assessment methodology for timber harvest around goshawk nests in the Northwestern California, Cascades Ranges and Modoc Plateau ecoregions (http://ncncr-isb.dfg.ca.gov/itp/).

References:

Anonymous. 1989. Goshawk breeding habitat in lowland Britain. British Birds 82: 56-57.

Austin, K. 1993. Habitat use by breeding goshawks in the southern Cascades. M. S. thesis. Oregon State University. Corvallis, OR

Beebe, F. L. 1974. Goshawk. Pp. 54-62 *In*: Field studies of the Falconiformes of British Columbia. British Columbia Provincial Museum Occasional Papers Series No. 17.

Beebe, F. L. 1976. The goshawk. Pp. 185-195 *In*: F. L. Beebe and H. M. Webster (eds.). North American falconry and hunting hawks. Fourth edition. North American Falconry and Hunting Hawks. Denver, CO.

Bent, A. C. 1937. Life histories of North American birds of prey. Part 1. U. S. National Museum Bulletin. No. 167.

Bloom, P. H., G. R. Stewart and B. J. Walton. 1985. The status of the northern goshawk in California, 1981-1983. California Department of Fish and Game. Administrative Report 85-1.

Bergstrom, B. J. 1985. Unusual prey-stalking behavior by a goshawk. Journal of Field Ornithology 56: 415.

Boal, C. W. 1994. A photographic and behavioral guide to aging nestling northern goshawks. Studies in Avian Biology 16: 32-40.

Boal, C. W. and R. W. Mannan. 1994. Northen goshawk diets in ponderosa pine forests on the Kaibab Plateau. Studies in Avian Biology 16: 97-102.

Bond, R. M. 1942. Development of young goshawks. Wilson Bulletin 54:81-88.

Bosakowski, T. 1999. The northern goshawk. Hancock House Publishers Ltd. Blaine, WA.

Bosakowski, T., B. McCullough, F. J. Lapsansky and M. E. Vaughn. 1999. Northern goshawks nesting on a private industrial forest in western Washington. Journal of Raptor Research *in press*.

Brier, P. and J. E. Drennan. 1997. Forest structure and prey abundance in foraging areas of northern goshawks. Ecological Applications 7: 564-571.

Bright-Smith, D. J. and R. W. Mannan. 1994. Habitat use by breeding male northern goshawks in northern Arizona. Studies in Avian Biology 16: 58-65.

Bull, E. L. and J. H. Hohmann. 1994. Breeding biology on northern goshawks in northeastern Oregon. Studies in Avian Biology 16: 103-105.

California Wildlife Habitat Relationships System. Version 7.0. California Department of Fish and Game.

Conner, R. N. 1979. Minimum standards and forest wildlife management. Wildlife Society Bulletin 7(4):293-296.

Crocker-Bedford, D. C. and B. Chaney. 1988. Characteristics of goshawk nesting stands. Pp 210-217 in: Proceedings of the Southwest raptor management symposium and workshop. National Wildlife Federation Scientific and Technical Series No. 11. Washington, DC.

Crocker-Bedford, D. C. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin 18: 262-269.

Daw, S. K. and S. DeStefano. 2001. Forest characteristics of northern goshawk nest stands and post-fledgling areas in Oregon. Journal of Wildlife Management 65(1): 59-65.

Desimone, S. M. 1997. Occupancy rates and habitat relationships of northern goshawks in historic nestling in Oregon. M. S. Thesis, Oregon State University.

DeStefano, S. and McMcloskey. 1997. Does vegetation structure limit the distribution of northern goshawks in the Oregon Coast Ranges? Journal of Raptor Research 31(1):34-39.

Detrich, P. J. and B. Woodbridge. 1994. Territory fidelity, mate fidelity, and movements of color-marked northern goshawks in the southern Cascades of California. Studies in Avian Biology 16:130-132.

Doyle, J. T. and J. N. M. Smith. 1994. Population responses of northern goshawks to the 10-year cycle in numbers of snowshoe hares. Studies in Avian Biology 16: 122-129.

Erickson, M. G. 1987. Nest site habitat selection of the goshawk (*Accipiter gentilis*) in the Black Hills National Forest of South Dakota. M.S. Thesis. University of South Dakota. Springfield, SD

Erlich, P. R. , D. S. Dobkin and D. Wheye. 1988. The birder's handbook: a field guide to the natural history of North American Birds. Simon & Schuster Inc. New York, NY.

Farber, S., S. Self, D. Miglaw, R. Carey, F. Barron and T. Boullion. 1998. Habitat relationships and habitat protection provided for northern goshawks on private forestlands in interior northern and central California. Report prepared for the U.S. Fish & Wildlife Service.

Fischer, D. L. 1986. Daily activity patterns and habitat use of coexisting Accipiter hawks in Utah. Ph.D. dissertation. Brigham Young University. Provo, UT.

Fleming, T. L. 1987. Northern goshawk status and habitat associations in western Washington with special emphasis on the Olympic Peninsula. Unpublished report. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. Olympia, WA.

Franklin, J.F., D. R. Berg, D. A. Thronburgh and J.C. Tappeiner. 1997. Alternate silvicultural approaches to timber harvesting: variable retention harvest systems. Pages 111- 139, *In*, K.A. Kohn and J.F. Franklin eds., Creating a forestry for the 21st century: the science of ecosystem management. Island Press, Covelo, CA.

Graham, R. T., R. T. Reynolds, M. H. Reiser, R. L. Bassett and D. A. Boyce. 1994. Sustaining forest habitat fo the northern goshawk: a question of scale. Studies in Avian Biology 16: 12-17.

Graham, R. T., T. B. Jain, R. T. Reynolds and D. A. Boyce. 1995. The role of fire is sustaining northern goshawk habitat in Rocky Mountain Forests. Proceedings - Fire Effects on Rare and Endangered Species and Habitats Conference. Coeur d'Alene, ID.

Gromme, O. J. 1935. The goshawk (*Astur atricapillus atricapillus*) nesting in Wisconsin. Auk 52: 15-20.

Hall, P. A. 1984. Characterization of nesting habitat of goshawks (*Accipiter gentilis*) in northwestern California. M. S. Thesis, Humboldt State University. Arcata, CA.

Hargis, C. D., C. McCarthy and R. D. Perloff. 1994. Home ranges and habitats of northern goshawks in eastern California. Studies in Avian Biology 16: 66-74.

Harris, J. 2000. U.S. Forest Service. personal communication. Comments received during Goshawk Working Group Meeting. May 18.

Harrisson, C. 1978. A field guide to the nests, eggs and nestlings of North American birds. William Collins Sons & Co. Ltd. Glasgow, UK.

Hayward, G. D. and R. E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. The Condor 91: 476-479.

Hennessey, S. P. 1978. Ecological relationships of accipiters in northern Utah with special emphasis of the effects of human disturbance. Logan, Utah: Utah State University. M. S. Thesis.

Ingraldi, M. F. and S. R. McVean. 1995. Nest-site selection by the northern goshawk in a ponderosa pine forest in east-central Arizona. Nongame and Endangered Wildlife Program Technical Report 47. Arizona Game and Fish Department. Pheonix, AZ.

Johnsgard, P. A. 1990. Hawks, eagles and falcons of North America. Smithsonian Institution Press, Washington and New York.

Keane, J. 2000. U.S. Forest Service. personal communication. Comments received during Goshawk Working Group Meeting. May 18.

Kennedy, P. L. 1989. The nesting ecology of cooper's hawks and northern goshawks in the Jemez Mountains, New Mexico: a summary of results, 1984-1988. Final report to Santa Fe National Forest. P.O. # 43-8379-8-346.

Kennedy, P. L. 1991. Reproductive strategies of northern goshawks and Cooper's hawks in north central New Mexico. Ph.D. diss. Utah State University. Logan, UT.

Kennedy, P. L., J. M. Ward, G. A. Rinker and J. A. Gessaman. 1994. Post-fledging areas in northern goshawk home ranges. Studies in Avian Biology 16: 75-82.

Kenward, R. E. 1978. Hawks and doves: factors affecting success and selection in goshawk attacks on wood pigeons. Journal of Animal Ecology 47: 449-460.

Kenward, R. E. 1982. Goshawk hunting behavior and range size as a function of food and habitat availability. Journal of Animal Ecology 51: 69-80.

Kenward, R. E. and P. Widen. 1989. Do goshawks need forests? Some conservation lessons from radio tracking. Pp 561-567 in B. U. Meyburg and R. D. Chancellor (eds.). Raptors in the modern world. World working group on birds of prey and owls. London, UK.

Long, J. N. and F. W. Smith. 2000. Restructuring the forest: goshawks and the restoration of Southwestern ponderosa pine. Journal of Forestry 98(8):25-30.

McGrath, M. T. 1997. Northern goshawk habitat analysis in managed forest landscapes. M. S. Thesis, Oregon State University.

Moore, K. R. and C. J. Henry. 1983. Nest site characteristics on three coexisting accipiter hawks in northeastern Oregon. Raptor Research 17: 65-76.

Morrision , M. L. 1992. Northern goshawk 1991 annual report. California Department of Fish and Game.

Opdam, P. 1975. Inter- and intraspecific differentiation with respect to feeding ecology in two sympatric species of the genus Accipiter. Ardea 63: 30-54.

Palmer, R. S. 1988. Handbook of North American birds. Diurnal Raptors (Part 1). New Haven, CT: Yale University Press.

Patla, S. M. 1997. Nesting ecology and habitat of the northern goshawk in undisturbed and timber harvest areas on the Targhee National Forest, Greater Yellowstone Ecosystem . M. S. Thesis. Idaho State University, Pocatello.

Reynolds, R. T. and H. M. Wright. 1978. Distribution, density, and productivity of accipiter hawks breeding in Oregon.

Reynolds, R. T., E. C. Meslow and H. M. Wright. 1982. Nesting habitat of coexisting accipiter in Oregon. Journal of Wildlife Management 46: 124-138.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting Accipiter hawks. USDA Forest Service General Technical Report RM-102.

Reynolds, R. T. and E. C. Meslow. 1984. Partitioning of food and niche characteristics of coexisting Accipiter during breeding. Auk 101: 761-779.

Reynolds, R. T. , R. T. Graham, M. H. Reiser, R. L. Basset, P .L. Kennedy, D. A. Boyce Jr., G. Goodwin, R. Smith and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. USDA Forest Service General Technical Report RM-217.

Reynolds, R. T., S. M. Joy and D. G. Leslie. 1994. Nest productivity, fidelity, and spacing of northern goshawks in northern Arizona. Studies in Avian Biology 16:106-113.

Reynolds, R. T., W. M. Block and D. A. Boyce, Jr. 1996. Using ecological relationships of wildlife as templates for restoring southwestern forests. In: Conference on adaptive ecosystem restoration and management: Restoration of Cordilleran conifer landscapes in North America. USDA Forest Service: RM-GTR-278. Fort Collins, CO.

Reynolds, R. T. and S. M. Joy. 1998. Distribution, territory occupancy, dispersal and demography of northern goshawks on the Kaibab Plateau, Arizona. Final Report, Heritage Project No. I94045. Arizona Game and Fish Department. Pheonix, AZ.

Richter, D. J. and R. Callas. 2000. Territorial occupancy, nest site use and reproductive success of goshawks on private and public timberlands, progress report - 1999. California Department of Fish and Game.

Saunders, L. B. 1982. Essential nesting habitat of the goshawk Accipiter gentilis on the Shasta-Trinity National Forest, McCloud District. M. A. Thesis, California State University, Chico.

Schaffer, W. W. 1998. Northern goshawk (Accipiter gentilis) habitat characterization in central Alberta. M. S. Thesis, University of Alberta, Edmonton.

Shuster, W. C. 1980. Northern goshawk nest site requirements in the Colorado Rockies. Western Birds 11: 89-96.

Squires, J. R. and L. F. Ruggiero. 1996. Nest-site preference of northern goshawks in south central Wyoming. Journal of Raptor Research 25: 132-135.

Squires, J. R. and R. T. Reynolds. 1997. Northern goshawk Accipter gentilis, pp. 1-32. In: Poole, A. and F. Gill (eds.), Vol. 298. The birds of North America. The Academy of Natural Sciences, The American Ornithologists' Union. Washington, D. C.

Saunders, L. B. 1982. Essential nesting habitat of the goshawk Accipiter gentilis on the Shasta-Trinity National Forest, McCloud District. M. A. Thesis, California State University, Chico.

Shipman, M. 1999. The northern goshawk (Accipiter gentilis): fledgling movements/use area. Webpage: http://www.blueplanetphotography.com/feature/gos9.htm

Schnell, J. H. 1958. Nesting behavior and food habits of goshawks in the Sierra Nevada of California. Condor 60: 377-403.

Spieser, R and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeast New York. The Condor 89: 387-394.

U. S. Fish and Wildlife Service. 1998. Northern goshawk status review. Martin, Catrina (team leader). Portland, Oregon.

U. S. Forest Service. 1992. Survey protocol for northern goshawks in the Southwestern Region. Federal Register. Volume 56(199):51672-51680.

Westcott, P. W. 1964. Unusual feeding behavior of a goshawk. The Condor 66: 163.

Widen, P. 1985. Breeding and movements of goshawks in boreal forests in Sweden. Holartic Ecology 8: 273-279.

Widen, P. 1987. Goshawk predation during winter, spring and summer in a boreal forest area of central Sweden. Holartic Ecology 10: 104-109.

Widen, P. 1989. The hunting habitats of goshawks *Accipiter gentilis* in boreal forests of central Sweden. Holarctic Ecology 10: 104-109.

Woodbridge, B. (data manager) 2001. NCal-Gos. MS Access database (draft 12/2001). USFS-USFWS Northern Goshawk Program. Yreka, California.

Woodbridge, B. 2000. U.S. Forest Service. personal communication. Comments received during Goshawk Working Group Meeting. May 18.

Woodbridge, B., P. J. Detrich and P. H. Bloom. 1988. Territory fidelity and habitat use by nestling northern goshawks: Implications for management. USDA Forest Service.

Woodbridge, B. and P. J. Detrich. 1994. Territory occupancy and habitat patch size of northern goshawks in the southern Cascades of California. Studies in Avian Biology 16: 83-87.

Younk, J. V. and M. J. Bechard. 1992. Effects of gold mining activity on northern goshawks breeding in Nevada's Independence and Bull Run mountains. Annual report. Raptor Research Center. Boise State University. Boise, ID.